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HATCH EXPERIMENT STATION

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MASSACHUSETTS

AGRICULTURAL COLLEGE.

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INJURIES TO SHADE TREES FROM ELECTRICITY.

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The regular Bulletins of this Station will be sent free to all newspapers in the State and to such individuals interested in farming as may request the same. Technical Bulletins are sent only to those persons interested in the subject treated of in each case.

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HATCH EXPERIMENT STATION

OF THE

Massachusetts Agricultural College,

AMHERST, MASS.

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HATCH EXPERIMENT STATION, Amherst, Mass.

Division of Botany.

GEORGE E. STONE.

Injuries to Shade Trees from Electricity.

Within the last few years increased interest has been manifested in shade trees and in road side improvement. This interest has been stimulated in Massachusetts by landscape gardeners and, more particularly, by the Massachusetts Forestry Association, the Massaachusetts Horticultural Society, and the State Board of Agriculture. Village Improvement Societies which have been in existence in some towns for many years have also become more active and numerous, and their interest in tree planting has been fruitful of good results.

Shade trees have many adverse conditions to contend with, which are becoming more numerous each year, and are likely to increase with the development of our cities and towns along present lines. Many of these difficulties can be obviated, if attention is given to their care and normal conditions of growth. Others, however, are not so readily disposed of and hence the trees must frequently suffer.

Some of the detrimental factors are the following:

Interference with soil moisture and root respiration by paved and macadamized roads and sidewalks.

Destruction of the root system by excavations for buildings, sewers, water, gas and steam pipes.

Interference of the root system by earth fillings and regradings.

Abnormal physical and chemical conditions of soil made up of refuse material, and of unsuitable soil texture causing an insufficiency or over supply of soil moisture.

Effects of soil covers as affecting water supply, etc.

Injuries arising from horses' teeth, abrasions from teams, etc.

Effects of exposure to various obnoxious atmospheric gases and smoke.

Lack of aseptic and antiseptic treatment in cases of wounds arising from accidental or intentional pruning, or from injuries from horses' teeth, abrasions from teams, etc.

Interference to tree growth by telephone wires.

Electrical injuries due to contact with alternating and direct current wires.

Injuries due to leaks in gas mains, steam conduits, etc.

Fig. 1. *Showing the destructive effect on the growth of a maple tree in contact with a mass of wires.*

These factors, singly or in combination, constitute a menace to trees, and it is only by an understanding of the effects that we can comprehend their importance as agencies detrimental to tree development, and obtain a rational conception of the aetiology of disease. Some of these factors are so detrimental to tree development that the largest species will succumb in a relatively short time. In most cases, however, trees subject to adverse conditions linger along in a state of *malaise* or weak condition, thereby easily falling a prey to parasites.

Insect and fungous pests are frequently troublesome. They are however often secondary, that is they frequently occur as a result of some weakened condition of the tree, arising from either a single cause or combination of causes. Moreover the changes which take place in its environment due to the introduction or expulsion of birds and insects frequently disturb the beneficial relationship existing between them to such an extent as to render pests more obnoxious. The general hygienic conditions, however, that are characteristic of our cities are

frequently so poor that the expectation of life of trees is frequently one-fourth to three-fourths of the normal.

Fig. 2. Showing injury by linemen's spurs on a young maple tree.

The increase of electric railroads, electric lighting systems and telephone lines which have their wires located, usually adjacent to the tree belt necessitates a large amount of disfiguration by pruning, and the close proximity of wires to trees too frequently causes a serious injury to them, in other ways. A tree that has been severely pruned or disfigured by a mass of wires is scarcely better than none. The telephone companies are satisfied if they can cut their way through the tree, the electric companies often take in addition to this privilege that of burning their way through. There are numerous instances where trees are planted under a mass of wires which are responsible for malformation and restricted growth, and it is only a question of time when either the trees or the wires must give way. In cities, where it has become expedient to bury the wires, we have one solution of the problem, but in towns this expensive process is not practiced to any great extent. In case of telephone wires a greater use of the cable would obviate much trouble; electric light wires, however, cannot be disposed of in this manner. The best possible way to get rid of them and, in fact, all overhead wires, if they cannot be buried, is to locate them as much as possible in the rear of buildings on private property.

Electrical injuries to trees cause the most complaint There are two kinds of currents in use in towns and cities, namely, the alternating and the direct. The voltage of the former may range from 1200 to 10000 volts. That of the latter is usually about 500 volts. These two kinds of currents produce different physiological effects upon vegetable life; the alternating current being apparently less disastrous to plant life than the direct current, and when

either is utilized at a certain strength it accelerates growth and development, or, in other words, it stimulates the plant.

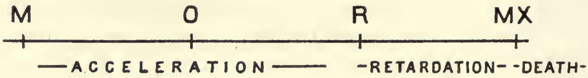

Fig. 3. *Diagram showing range of electric current affecting plants. M—minimum. O—optimum, or current producing greatest stimulus. MX—maximum, or death current. R to MX—retardation current.*

There is a minimum, optimum and maximum current. The minimum represents that strength of current which just perceptibly acts as a stimulus. The optimum that producing the greatest stimulus and the maximum that causing death. Between the optimum and the maximum there is a strength of current that causes retardation, this being represented between r and mx in figure 3.

The direct current stimulates less than the alternating, and on account of its polarizing effect, appears to cause more injury to vegetable life than the same strength of alternating current. Most of the injurious electrical effects to trees arising from trolley or electric light currents are, as a rule, local: that is, the current causes an injury at or near the point of contact of the wire to the tree. This injury is produced in moist or wet weather, when the tree is covered with a film of water. This provides favorable conditions for leakage, the current traversing the film of water on the tree to the ground.* The result of contact of a wire to a limb, under these conditions, causes a grounding of the current, and a burning of the limb of the tree due to arcing. The vital layer of the limb may become partially or entirely killed at the point of contact which may result in an ugly scar or greatly disfigure the tree. In a large number of tests made by the aid of sensitive instruments upon the connections of feed wires to trees by means of guy wires we have never found any leakage during fair weather, although such may occur in wet weather, especially when the voltage is considerable. Since the amount of current that can be passed through a tree depends upon the resistance and voltage it will be well to consider the resistance exhibited by some trees.

*Note.—It is not an uncommon thing during wet weather to observe cases of electrical shock produced by touching trunks of trees where leakage occurs. The writer has observed apple trees which were accidentally charged, by being in contact with uninsulated feed wires through guys, where the fruit was perfectly safe.

ELECTRICAL RESISTANCE OF TREES.

The electrical resistance exhibited by trees is quite large, otherwise considerable more injury might result when live wires carrying strong currents are brought in contact with them. The resistance offered by 10 feet of the trunk of a maple and elm tree, 12 in. and 18 in. in diameter respectively, is as follows:

TABLE SHOWING THE RESISTANCE OF DIFFERENT TISSUES OF THE MAPLE AND ELM TREE.

	Maple. (Ohms).	Elm. (Ohms).
Outer bark,		192000
Middle of inner bark (cortex),	29900	11300
Cambium (vital layer),	18000	10698
Wood, ¼ in. in from cambium,	138000	98700

These figures which are the result of only one test taken during the month of June show that trees possess considerable electrical resistance. Such resistances as are shown in the table are capable of cutting down tolerably high currents to an insignificant amount. As might be expected, the cambium or vital tissue and the inner bark, containing the phloem, show the least resistances. The resistance of the outer bark of the elm tree was reduced quite perceptibly after turning a hose on it for four hours. The bark, however, in the elm is more differentiated than in the maple, and the electrodes in the middle or inner bark test in the elm were pratically in the layer known as the phloem.

Experiments have shown that those layers containing large amounts of the sugar compounds have the smallest resistance, and since these layers which contain sugar are close to the cambium, one would naturally expect on this account to find the smallest resistance in them. These resistances were taken with a Wheatstone Bridge. Others have been estimated from the voltage and current passing through the tree. In all cases the electrodes or wires were driven into the tree so as to penetrate the wood. Some of these are as follows:

A maple tree, 18 in. in diameter, gave a resistance of 20000 ohms for 16½ ft. of its trunk. The same tree gave 11000 ohms for 7 ft. of the trunk, and 7000 ohms for one foot.

A pear tree, 2 ft. 8 in. high, 1¼ in. in diameter at the base, gave a resistance of 290000 ohms when the current passed from the root

extremities to the top of the tree, or practically a distance of 3 ft.

A sunflower seedling, 17 in. high, and 3-16 in. in diameter, gave a resistance of 25000 ohms for 1 in. of stem, and 3 in. of the root, while a slightly larger plant of the same species gave 7500 ohms, for 1 in. of stem, and ½ in. of moist soil.

THE EFFECTS OF ALTERNATING CURRENTS.

Fig. 4, Showing the effects of electrical burning and strangulation.

The voltage and current of alternating systems employed for lighting purposes are much greater than those utilized by street railways, and the cases of burning of trees by alternating currents are probably more numerous than those produced by direct currents, for the reason that a larger number of these wires are in the tree belt. Some alternating feed wires in use carry enormous currents. The higher the current a wire carries, the more dangerous it is to trees, for insulation in such cases is less effective and hence arises more leakage and a greater possibility of burning. According to our observations, the effects of alternating currents on trees are local, that is, they produce injury only near the point of contact. This results in the death of that portion of the tree where the burning occurs, and if it is a leader or a large limb it frequently has to be sacrificed, much to the detriment of the tree. A portion of a tree below the point of contact is frequently affected, the extent of injury varying with the electrical potential of the wire, etc. In no instance, to our knowledge, has the alternating current caused the complete death of trees. It may, however, burn and disfigure young trees so badly that it practically amounts to complete destruction. The alternating current is, however, capable of killing plants, as we have frequently demonstrated in the laboratory, with a current from a 110 volt system. The current necessary, however, to accomplish this, generated considerable heat.

Fig. 5. *Showing deep burning of a large limb, caused by an alternating wire of high potential. From Luke Doogue, City Forestry Dept., Boston.*

Death in such cases resembles that from heat, as the maximum death temperature is quite similar in each case. The collapse of the plant in such cases is due to the heat generated, rather than to an electrical shock, inasmuch as it is possible to pass the same current through plants, under conditions where heat is not generated, without causing any damage to the tissues. It is generally believed that the arc light is injurious to trees. We have never been able to discover any injuries resulting from the use of the arc light, and we have observed hundreds of cases where the light was in close proximity to trees. Many plants will die, or linger along in a sickly condition, if subject to poor soil conditions, and given an insufficient supply of food material. Such cases of death, however, should not be attributed to the supposed injurious effects of the electric light.

EFFECTS OF DIRECT CURRENTS.

Most of the direct currents that trees have to contend with are those generated in operating electric railroads. The electro motive force generally employed on these circuits is about 500 volts. The feed wire not infrequently passes through the tree belt, and occasionally it comes into contact with the limbs of the trees. Although the voltage and current are less on this system than on the lighting system, electrical injuries are likely to prove fully as disastrous. The great majority of burns resulting from the direct current are similar to those produced by the alternating current, namely, they are largely local, that is, the burning predominates close to the point of contact with the wires. The feed wires cause no burning to the tree when

brought in contact with it, except when the trees are moist in which case a grounding occurs. The very high resistance exhibited by plants, in general, furnishes a means of protection against death by electrical contact with ordinary currents applied in the usual way. Under peculiar conditions electrocution of trees has taken place. This subject, however, will be referred to later.

Fig. 6. Showing disfigurement of trees, caused by electric wires. From W. F. Gale, City Forester, Springfield, Mass.

A number of experiments have been made by us showing the amount of current that will pass through plants. These experiments have been made on large trees and small succulent plants. In a number of instances, a wire was passed from the tree to the rail or ground, and another wire was connected to a bare feed wire leading to some other portion of the tree, a milammeter being placed in the circuit to obtain the actual current. Electrodes, which were made of nails attached to the end of No. 18 insulated wires, penetrated into the wood. The results were as follows: 16½ ft. of a maple tree, 18 in. in diameter, gave 25 milliamperes, (1-40 amp.*), 7 ft. of the same tree gave a current of 45 milliamperes, (1-22 amp.) and 1 ft. of the trunk gave 70 milliamperes, (1-14 amp.). These experiments were made on a dry day, and no

*Ampere.

heat developed at the point of insertion of the wires or electrodes, neither was there any change in the reading of the milammeter after being connected for some minutes. The latter connection was left on the tree for several months. The attachment with the uninsulated feed wire, however, occasionally became misplaced, and the exact length of time when a definite contact was made is not known. There was a contact during periods of wet weather at which time there was always considerable heat developed where the positive wire was connected with the tree, but not enough to melt soft solder which connected the wires with the electrodes. Examination of the tree ten months later showed that a portion of the tissues near the electrodes had been killed. After removing the dead bark, an oval space, 6 by 11 in. was found to be dead about the positive electrode and a space about 1½ x 3 in. near the negative electrode. The burned area about the positive electrode was about 95 per cent more than occurred about the negative electrode. In each case it extended about twice as far above and below the point of contact as to the sides of the electrodes, thus showing a tendency of the current to travel in a vertical direction rather than laterally.

The immediate portions around the electrodes were more affected than those further remote. There was an area of tissue about 5 in. long between the large and small oval burning that was uninjured, showing that burning was confined about the area of the electrodes, and the current did not burn a groove from one pole to the other. The current traversing the film of water on the bark was necessarily small, at least not sufficient to do any damage at a short distance from the electrodes. The results obtained by passing a current for a brief period through 16 1-2 ft. and 7 ft. of the tree trunk showed no effect on the tissues. A young pear tree, 2 ft. 8 in. high, 1¼ in. in diameter at the base, which had been grown one year in a box, 14 by 16 by 9 inches, and provided with a copper plate in the bottom in direct contact with the roots, showed a current of 2.2 milli-amperes, (1-454 amp.), when one electrode was connected with the copper plate, and the other with the top of the tree. Connections made with a poison ivy plant growing on a tree showed in most cases similar results when the electrodes were inserted into the stem 2 in. apart. A stem 3-4 in. in diameter gave a current equal to 4.4

milliamperes, (1-227 amp.), ½ in. in diameter, 25 milliamperes, (1-40 amp.), and on another of the same size, 50 milliamperes, (1-20 amp.). In the latter case, and some others not included here, the currents went down from the 50 milliamperes to nothing almost instantly. From these experiments it would appear that the current burned out the cambium, or vital layer of the stem, thus leaving the dry and highly resistant wood which was unable to transmit a current that was perceptible.

Some young sunflowers and tomato plants grown in 3 in. pots, with copper plates at the bottom, were treated from a direct current dynamo which generated an electro motive force of about 60 volts. The plants were from 6 in. to 2½ ft. high, and ⅛ to ¼ in. in diameter. The current passing through the soil and roots in 16 in. of stem of the Helianthus plant, 3-16 in. in diameter, gave a reading that was scarcely perceptible. When, however, it passed through only one inch of the stem and root to the copper plate at the bottom, the maximum current was 2.6 milliamperes, (1-384 amp.). This caused blackening and death of the tissues which were perceptible a few hours afterwards about the points of insertion of the electrodes on the stem, and the plant was girdled for about 2-3 of its circumference. Practically similar results were obtained with other sunflower plants treated in the same way. A sunflower, 30 in. high and 1-4 in. in diameter, subject to a current of 10 milliamperes for some minutes was not injured to any extent. In this case the current passed through about 1 in. of stem and ½ in. of soil. A young succulent tomato plant, ⅛ of an inch in diameter and 5 in. high, was instantly killed when treated in the same manner, with a current of 20 milliamperes. A current equal to 2 and 3 milliamperes of 30 to 60 seconds duration, accomplished the same result. In all the tomato plants considerable heat was developed. The tissues changed color, and the plants collapsed, although in one case where an alternating current was employed the collapsed plant lived for a number of days, as the vascular bundles, or water conducting tissues, were not injured.

There are certain instances, however, where large trees have been killed by direct currents employed by electric railroads. In some cases which have come under our observation, the escaping current had girdled trees at the base, a distance of 5 to 10 ft. in height, whereas, the point of contact of the feed wire to the limb, 16 or 18

ft. above, showed none of the characteristic burning effects. The general physiological effects in these cases were so different from

Fig. 7. Maple tree killed by direct current from a trolley system, carrying positive current through the rail, and return current through the feed wire in contact with branches. The largest amount of burning occurred slightly remote from the poiut opposite the rail, and in line with a large root, lying diagonally with, and just under the nearest rail.

Fig. 8. Elm tree killed by a direct current from an electric railroad system carrying positive current in the rail, and return current in the so-called feed wire in contact with the branches.

those usually of the kind, occurring as a result of the electrical contact of live wires with the trees, that it was quite evident something very unusual had taken place in these instances. On electric railroad systems, the positive current almost universally traverses the feed wire, and it is at the point of contact with the feed wire that most injury takes place. In all cases where trees were killed by electricity, this condition of things was reversed, namely, the positive current was conducted through the rail, and the return current through what is usually the feed wire. How common the practice has been of operating on this system, we cannot say. Nevertheless, it has been practiced, unintentionally perhaps, by various companies at one time and another. Such practice is responsible in some instances for the killing of shade trees adjacent to the rails. Undoubtedly the conditions at the base of the tree are much more favorable than near the limbs for extensive burning. The moisture condition of the soil and bark are such that the resistance, would be reduced and cause the current to spread over a large area. It is evldent in this case, at any rate, that the current had gained access to a large area of the cambium layer, thus girdling the tree to a considerable distance, that portion of the tree trunk towards the rails being more severely affected than that away from the track. There were no deep burning effects on the trunk, either above or below in any of these instances, as is quite customary when the positive wire comes into contact with the tree. The area, however, affected about the base of the tree was decidedly larger than that usually occurring when the positive or feed wires are brought into contact with limbs. Shortly after the trees were injured, the bark could be readily removed from the trunks, and later fell off. The trees killed were elms and maples, 18 in. or more in diameter, and in each case they were in the legitimate tree belt, being about three feet from the rails. These experiments and observations, pertaining to the effects of the direct current on plants, demonstrates that we have a variety of conditions to deal with, in considering the effects of electricity on trees.

A current can be increased in two ways, namely, by decreasing the resistance or increasing the voltage. If the voltage of the trolley system is increased to 5000, we would obtain a current equal to only 250 milliamperes in the experiment where we obtained 25 milliamperes, through 16½ ft. of the maple trunk ; and it will require a

voltage of 20000 to give one ampere current through this same tree under similar conditions. In like manner the resistance would have to be reduced from 20000 to 500 ohms, in this experiment, in order to obtain one ampere current. In the experiment where the wires were only one foot apart, the current was 70 milliamperes, and there was no evidence that a particle of heat developed during dry weather. The current that will kill a young succulent plant will not kill a tree, or cause it any injury, for example, a current of even three milliamperes or less will kill a young plant. whereas the same plant, when more matured, would require a much stronger current to kill it. From this it will appear that a current that will kill one plant in one stage of development, will not in another. There is therefore as great a range in current required to kill plants as there are stages of development or individual peculiarities, and it is impossible to state only in particular cases and under certain conditions, what a current of a definite strength is capable of doing. There are many factors which enter into a problem of this nature: such as the character of the plant juices which the current has to traverse, the area of cross section of the conducting tissue, and the conditions under which the current is applied. An electric current may pass through a wire of large diameter and cause no heating, whereas the same current passed through a very small wire will produce intense heat.

Fig. 9. Showing the characteristic grooves on the trunk of an elm tree caused by a feeble stroke of lightning.

A current has plenty of opportunity to spread in a tree, even if confined to a single tissue, hence, in order to obtain a current which will produce heat, it has to be quite strong in a large plant, whereas, in a small plant, heat will develop with less current. The amount of current required to kill a maple tree, 18 in. in diameter by burning will have to be comparatively strong, provided the current has to pass through a considerable portion of the tree. If the current, however, is confined in its action to a limited area where the amount of resistance is small, and where considerable heat can be developed, such as might be produced by passing it around the tree, or girdling it, disastrous results might follow from the use of not very strong currents, on account of its being confined to a limited vital area.

Fig. 10. *Showing the effect of earth discharges through a tree, causing splitting of the trunk and destruction of limbs.*

From these observations it is quite clear that, notwithstanding the high resistance of plants, and the limited amount of current, which it is possible to pass through, there may prevail a combination of conditions which may prove injurious or fatal to the organism. The negative results obtained by passing currents through trees, under certain conditions, does not necessarily prove that death from electrical injuries may not result. It might be possible for trees, in contact with uninsulated wires, to be subject to a strength of current which

would not cause any perceptible burning but which would produce a retarding effect in the plants' activities thus resulting in a weakened condition of the tree. If, for example, a tree was subjected to a current of a strength equivalent to that represented between r and mx in Figure 3, page 6, (retardation current), it would be subject to over stimulation which might result in its becoming sickly and ultimately dying. Indeed, such a case might not only be possible, but is extremely probable, inasmuch as a few instances have come under our observation where trees were apparently dying from this cause, without any indications of burning. Such cases, however, are extremely rare. Then again lightning arresters, when placed near trees, may succeed in causing injury by discharges. This opinion, however, is merely conjectural, although it has the support of some observations. It is known that occasional leakage takes place through the soil, as is manifested by the behavior of sensitive instruments commonly used in laboratories. Probably the amount of ground leakage which may occur through imperfect rail connections, thus charging water and gas pipes and occasionally charging the soil, would not cause any perceptible injury to trees.

On the whole, the cases of killing trees by escaping electricity are very rare, and by no means so numerous as is generally believed. Because a large number of trees, adjacent to electric railroads, happen to become sickly, it must not be concluded that electricity is the cause of these abnormal conditions in all cases. In cities and towns, where most of the sickly specimens exist, there are various adverse conditions with which trees have to contend. It is, therefore, quite essential, in diagnosing diseased conditions that these various factors be taken into consideration before forming definite opinions as to the real cause responsible for their abnormal condition.

LIGHTNING.

The common effects of lightning strokes upon trees are so well known that it is not necessary to dwell upon them here. Lightning, however, does not always strike a tree in the same manner, or produce the same results, and the peculiar effects which it displays are often interesting. Sometimes trees are killed outright by lightning without displaying any of the common effects of shattering. Appar-

ently in such cases the discharge is dispersed in such a way as not to cause visible mechanical injury to the tree. The girdling of a larger or smaller area of the living zone or cambium layer of the trunk would be sufficient to cause its death. Quite frequently this is accomplished by the discharge taking a spiral course. In a very large number of instances of lightning stroke neither death nor mechanical injury of importance takes place. Hundreds of trees are annually struck by lightning that are never recognized except by those who know how to interpret the small vertical lines or creases which subsequently make their appearance on the trunk. (See Figure 9.) There are many cases of lightning stroke that appear to offer examples of discharges from the earth. The effect of such discharges on the tree are quite characteristic and not at all similar to the ordinary forms of lightning strokes. Probably the nature of the soil conditions have much to do with such discharges, although it must be confessed that little light has been shed upon this subject. Our attention was called two years ago to some tree belts located in a town in the eastern part of the State, where lightning had apparently caused some damage. These trees are maples from 5 to 18 inches in diameter, growing in soil composed in most places of gravel containing apparently oxide of iron, and underneath this I am informed there is a stratum of quick sand.

Fig. 11. Showing the effect of earth discharges through the tree, causing splitting of the trunk and destruction of limbs.

A considerable number of the trees growing in this territory show the effects of earth discharges and in some cases they have been replaced for the third time only to be mutilated and disfigured by electrical discharges. These discharges occur during thunderstorms, and Mr. C. F. Jackson who has these trees under his supervision and has observed them for many years relates that the discharge gives rise to a dull characteristic report, resembling the effect of throwing a wet cloth on a hard surface. The discharge, however, does not affect the whole tree, but only part of it. Such for example, as one side of the trunk and one or more of the limbs, usually the lower ones on the same side as that portion of the trunk affected. The first indication of the discharges are shown by the wilting of the leaves of the affected limbs which results in their drying up and dying, with the subsequent loss of the limbs. In the course of time creases can be seen on the trunk showing the path of the discharge, and occasionally when the injury is considerable the bark falls off near that portion affected. The limbs, however, are not always killed, though frequently becoming split; (see Fig. 12) and a split-

Fig. 12. *Showing the effect of earth discharges through the tree, causing splitting of the trunk and destruction of limbs. The arrows indicate badly split limbs.*

ting of the wood for some depth is now and then observed on the trunk along the path of discharge. Sometimes these earth discharges kill the tree, but in most cases only a disfigurement occurs, which, however, may be great enough to destroy its symmetry. A very much larger number of trees than people are aware of show earth discharges. In most cases of this kind the discharge affects one or more limbs, as the current seldom follows up the main trunk but discharges at the points of several branches. MacDougal* mentions some trees which appear to have been injured by earth discharges. Whether the chemical composition of the soil has any particular bearing upon earth discharges is not positively known. It is known, however, that there frequently exists great differences in the electrical potential between the earth and air during thunderstorms and that the electrical conditions of the clouds and earth may change instantly from negative to positive. Some observations made by Mr. A. C. Monahan in our laboratory with a Thomson self-recording quadrant electrometer and water dripping collector show that the electrical potential of the atmosphere varies from a negative charge of 75 volts to 300 positive at various times, at a distance of 30 feet from the ground, and it is also known that trees occasionally discharge sparks at their apices, showing that insignificant earth discharges occur through trees.

SUMMARY.

The adverse conditions with which shade trees have to contend, in cities and towns, constitute a serious drawback to their development.

A considerable amount of damage occurs to shade trees by wires, causing abrasions, destruction of limbs and leaders, burnings, and necessitating much injudicious pruning.

The greatest amount of damage caused to trees by alternating and direct currents is by local burnings. The higher the electro motive force (voltage), the more injury is likely to occur to trees.

There is practically little or no leakage from wires during dry weather. In wet weather, however, when a film of water is formed on the bark, more or less leakage is likely to occur, and if the

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insulation is insufficient and contact with the tree exists, grounding takes place, and burning due to arcing, results.

No authentic cases have been observed by us where the alternating current, employed for lighting service, has killed trees, though there are authentic cases, extremely rare, where the direct current, used in operating street railroads, has killed large shade trees. This has been accomplished by reversing the polarity, causing the positive current to traverse the rail, and the return current the feed wire, which usually carries the positive.

The high resistance offered by trees and plants, in general, serves as a protection against death from an electrical contact.

The least resistance in trees occurs in the vital layer, (cambium), and those tissues adjacent to it.

Electric currents of whatever nature, when applied to plants of a certain intensity, act as a stimulus.

The physiological effect of the direct current on vegetable life differs from that of the alternating: the latter current acts more as a stimulus to the plant than the former.

There is evidence to support the idea that a current, of not sufficient strength to cause burning, may over stimulate the plant and cause a retardation of its activities which will subsequently result in death.

Earth discharges during thunderstorms are more common than generally supposed, and they are known to disfigure and cause the death of trees.